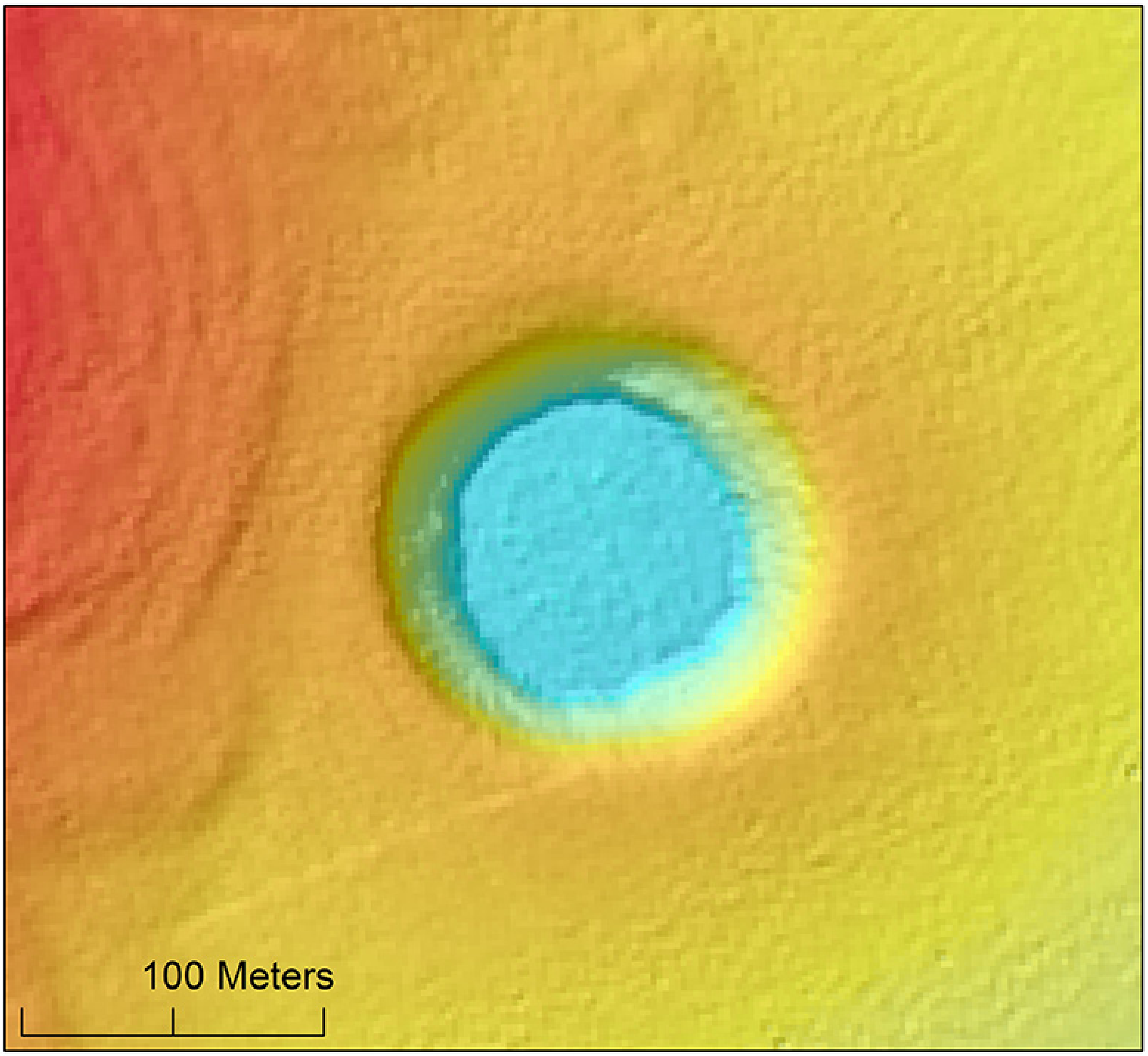
Pockmarks on the lake bed

May 18 2015, by Peter Rüegg



The Chez-le-Bart crater ("Crazy crater") has a diameter of 160 m and is one of the largest found in a freshwater lake. Credit: from Reusch et al. 2015

An unusual and unexpected discovery: on the floor of Lake Neuchâtel, geologists have happened upon huge underwater craters—some of the largest in the world to be found in lakes. They are not volcanic in origin, but were caused instead by giant freshwater springs.

Anna Reusch, a doctoral student at ETH's Geological Institute, was utterly amazed one morning: during a routine measuring run with her research vessel on Lake Neuchâtel, she suddenly saw an unusual shape on the control panel screen. Beneath the boat, at a depth of over 100 metres, had to be something no one had ever seen before. She immediately informed her professor, Michael Strasser: "We've found something that you absolutely have to see."

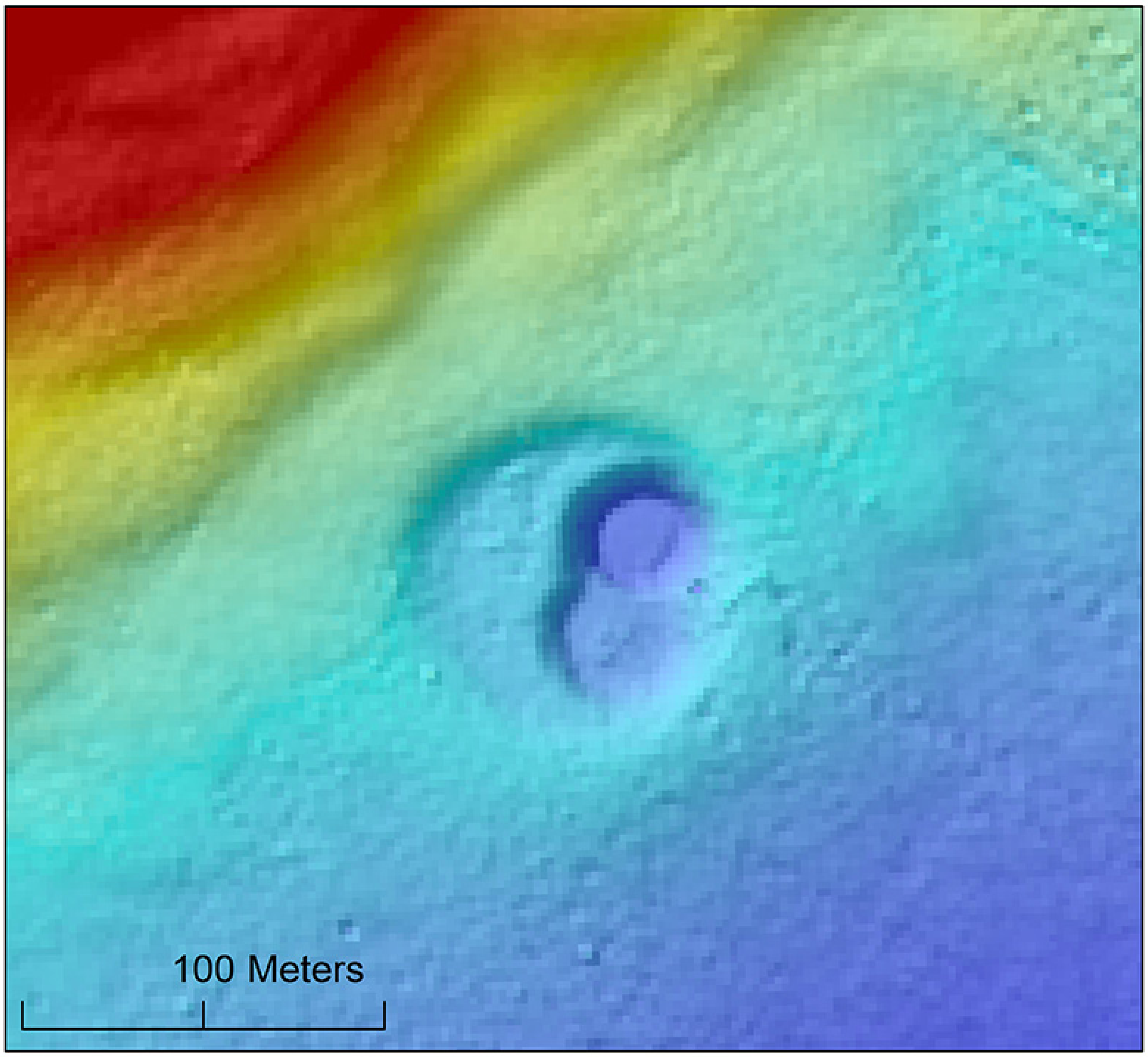
An initial rough data analysis on board indicated that Reusch and her colleagues were looking at a scientific sensation: an enormous crater, measuring 10 metres deep and 160 metres in diameter. "I'll remember this day for a long time - I never expected anything like this," recalls Reusch, adding: "It just goes to show that even in the 21st century, there are still thrilling and exciting discoveries to be made in Switzerland!"

Searching for signs of earthquakes

Reusch made this discovery as part of "Dynamite," a project sponsored by the Swiss National Science Foundation. The objective of her subproject is to investigate the sediment in the lakes on the western Swiss Plateau for traces of past earthquakes. Her work involves taking high-resolution measurements of the floor of Lake Neuchâtel to find evidence of tectonically active zones that could trigger major earthquakes. The period Reusch is looking at is geologically speaking very recent: sometime in the past 12,000 years.

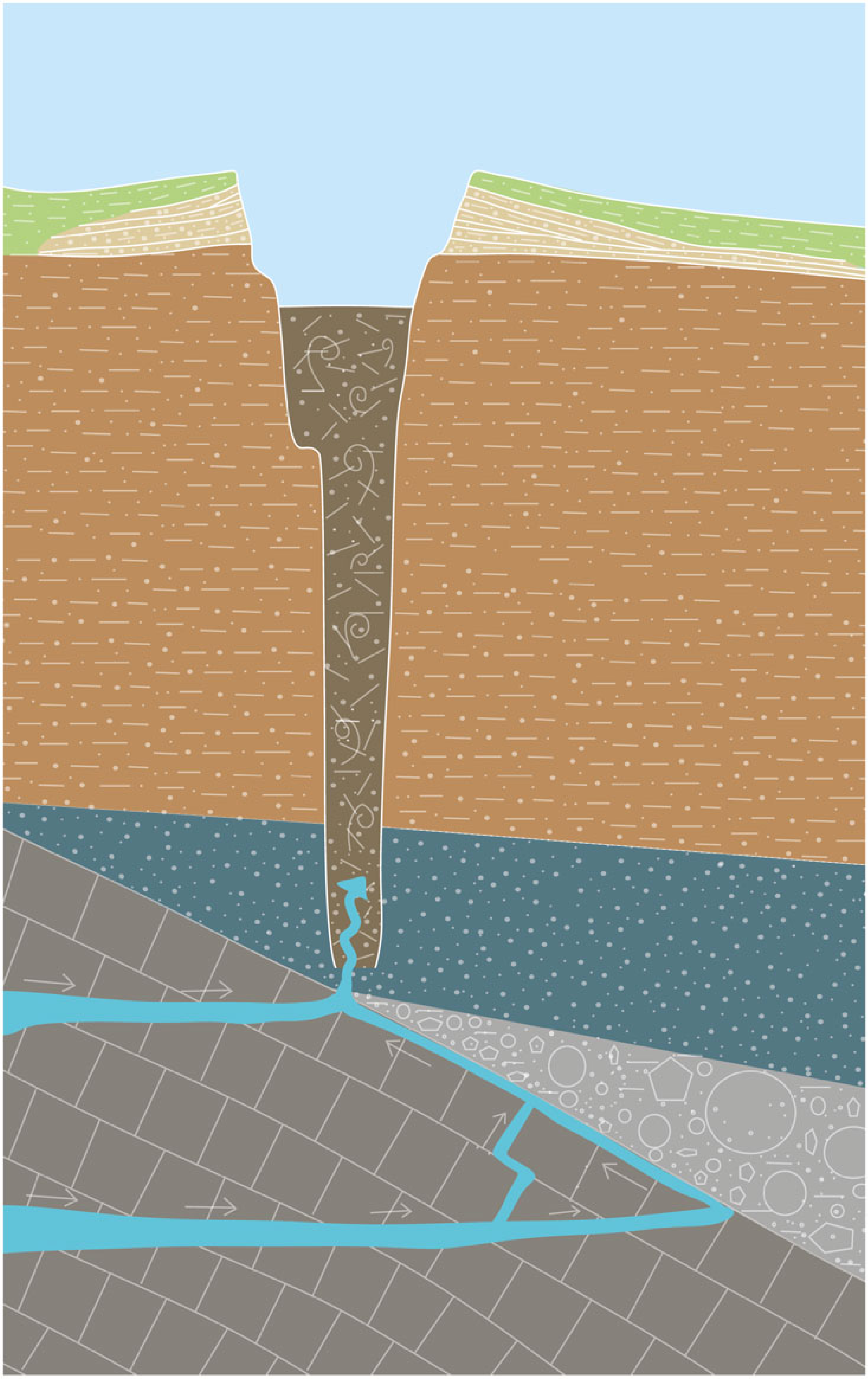
But the discovery of the enormous crater and subsequently of other similar structures has turned her doctoral dissertation almost completely upside down. "The craters were so interesting that we simply had to take a closer look at this phenomenon," she explained.

Four lake craters



The Treytel crater consists of three parts, an older large and two smaller craters, still expelling water actively. Credit: from Reusch et al. 2015

All in all, the research team located four craters on the lake bed. All are off the northwest shore at a depth of over 100 metres, with most of them in an area extending from known tectonic fault zones. The researchers have described the four craters in a paper that was recently published in *Geophysical Research Letters*.



Scheme of Crazy Crater. Credit: ETH Zurich / based on Reusch et al. 2015

The craters measure 80 to 160 metres in diameter and between 5.5 and 30 metres in depth. Researchers nicknamed the largest of them "Crazy Crater", not just because of its uncommonly generous proportions, but also because of its unusual shape: whereas comparable structures on the ocean floor usually lose their shape through the action of currents, this one is perfectly round.

Filled with mud

At the foot of the 10-metre-deep Crazy Crater, the researchers were able to make out a mud covering. Beneath it lies a 60-metre-deep vent, filled with a thick suspension of water and sediment. The team was unable to take core samples because the material was too fluid, due to water welling up into the vent from below. This keeps the sediments in the vent in motion, ensuring that they can't settle into a solid state as normal lake sediment does.

By measuring the isotope fingerprint plus the temperature of the water, suspension and sediment, the scientists were able to show that it was water flowing up into these craters as opposed to, say, gas. Whilst the suspension had a temperature of 8.4 degrees Celsius, both the deep water and the sediment surrounding the crater measured just 5.8 degrees. This corresponds to the normal temperature of the water at that depth in these lakes. By contrast, the temperature of the suspension is comparable to that of the surface water in the bordering karst area.

The suspension inside the vent also contains a smaller proportion of the heavy oxygen-18 isotope than does the surrounding lake water. "The difference in these oxygen signals indicates that we're talking about two distinct bodies of water here," says Reusch.

Gigantic spring

For this reason, Reusch believes it is most likely that the craters are linked to the karst systems of the neighbouring Jura Mountains. Water there seeps underground, flows beneath the bed of Lake Neuchâtel and seeks out the path of least resistance up to the surface. That takes the water up through sediment layers over several tens of metres thick that have been deposited on the lake bed over the millennia. "In other words, these craters are in fact springs," explains Reusch.

Furthermore, the researchers were able to use sediment core samples taken from the area directly surrounding the craters to show that the suspension spills over the lip of the crater from time to time, similar to a volcanic eruption. This has happened at least four times over the past 12,000 years - and yet despite today's active water flow, it has been more than 1,600 years since Crazy Crater discharged any sediment on the crater levee. Exactly what triggers these eruptions still needs to be investigated. "Researching the dynamics of the craters requires long-term monitoring to keep an eye on the water level of the suspension in the crater," says Reusch.

Explorer fever

All of the craters explored so far lie 100 metres or more beneath the lake 's surface. Reusch cannot say whether or not there are similar "pockmarks" in the shallows, as she has used sonar to sound only the deep parts of Lake Neuchâtel (30 metres and deeper). The shallow zones have not yet been mapped.

When taking measurements in the lakes, the researchers use a sophisticated multibeam echo sounder, a device used primarily for surveying the ocean floor. Depending on the water depth and the angle of the beams, the device achieves a resolution of up to 20x20 centimetres. At the moment, the sounder has plenty to do: the floor of Switzerland's lakes remains relatively poorly researched in comparison to the terrain on land. Researchers began examining the bottom of many Swiss lakes with high-resolution methods only a few years ago, and have discovered phenomena in their depths that no one suspected even existed.

More information: Reusch A, Loher M, Bouffard D, Moernaut J, Hellmich F, Anselmetti FS, Bernasconi SM, Hilbe M, Kopf A, Lilley MD, Meinecke G, Strasser M. Giant lacustrine pockmarks with subaqueous groundwater discharge and subsurface sediment mobilization. *Geophysical Research Letters*, 13 May 2015, DOI: 10.1002/2015GL064179

Provided by ETH Zurich